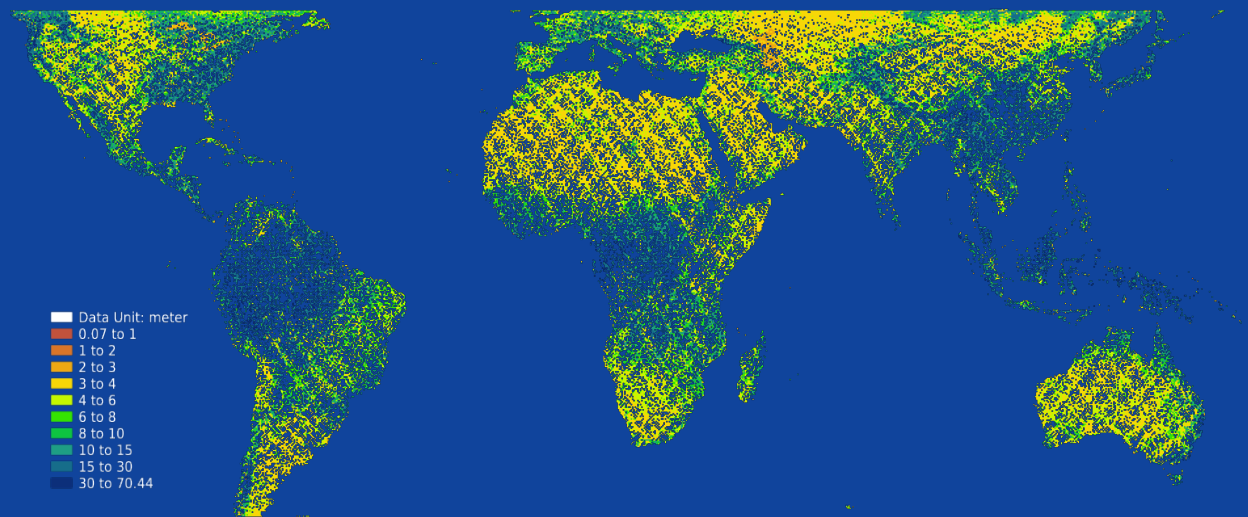


# Synergistic Use of SAR and Lidar Data for Terrestrial Ecology Research

Overview of ORNL DAAC data and tools for terrestrial ecology research

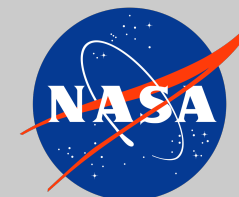
*Rupesh Shrestha (ORNL DAAC)*  
*Michele Thornton (ORNL DAAC)*  
*Yaxing Wei (ORNL DAAC)*



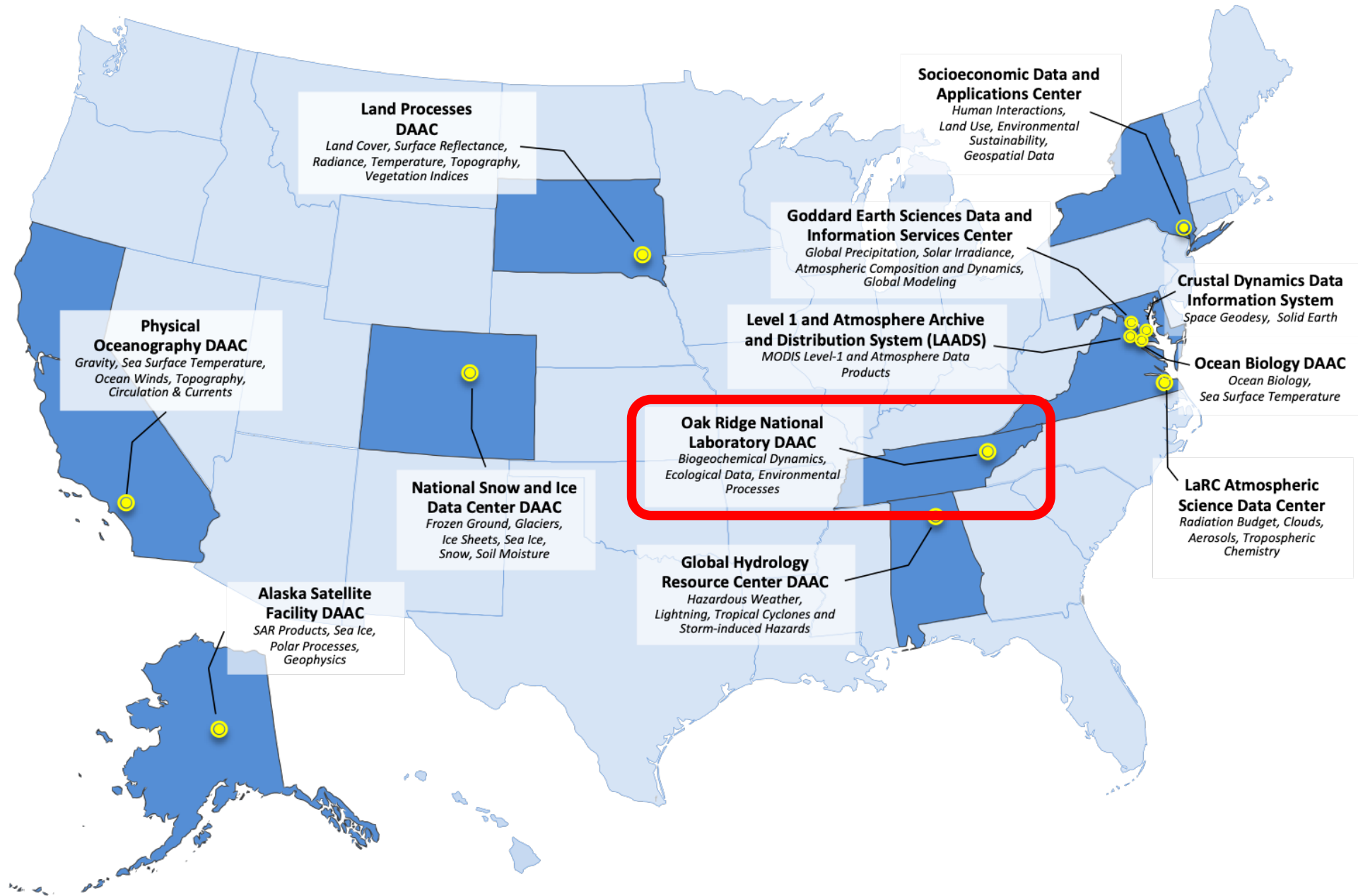
The Oak Ridge National Laboratory Distributed Active Archive Center for Biogeochemical Dynamics operates under an interagency agreement between NASA and the U.S. Department of Energy



**U.S. DEPARTMENT OF  
ENERGY**



# EOSDIS Distributed Active Archive Centers (DAAC)s



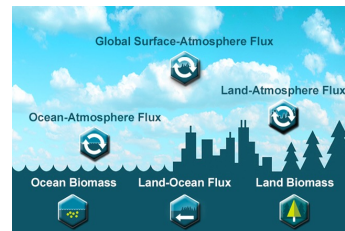
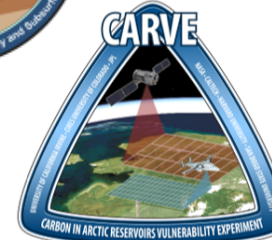
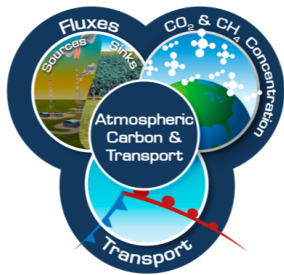
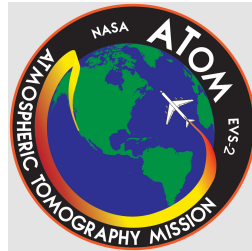
# About ORNL DAAC

- Mission
  - Assemble, distribute, and provide data services for a comprehensive archive of terrestrial biogeochemistry and ecological dynamics observations and models to facilitate research, education, and decision-making in support of NASA's Earth Science.

The screenshot shows the ORNL DAAC website homepage. At the top is a navigation bar with links: Home, About Us, Get Data, Submit Data, Tools, Resources, Help, and Sign in. Below the navigation bar is a search bar labeled "Search ORNL DAAC" with a "Search" button. The main content area features a large map of the United States with a color-coded overlay representing temperature data. Below the map is a banner for "Daymet Version 4 Data Products highlighted by NASA's Earthdata" with a subtext: "Daymet Version 4's improved algorithm and sensor timing and bias corrections result in more accurate and precise data." Below the banner are four boxes representing different data categories: Field Campaigns (1086 Datasets in 14 Projects), Land Validation (32 Datasets in 6 Projects), Regional/Global (403 Datasets in 12 Projects), and Model Archive (16 Models in 1 Project). Below these boxes is a "News" section with a "More News" link. The news section contains four articles: "Upcoming NASA Earthdata NSIDC Webinar" (IceFlow and icepyx: Python tools for Harmonizing Laser Altimetry Datasets to be presented on April 28, 2021 at 2:00 p.m. US Eastern Time), "NASA Earthdata Article Highlights Delta-X Airborne Mission" (NASA researchers are using high resolution airborne data to determine vulnerability and resilience of the Mississippi River Delta), "Daymet V4 2020 Data Recently Released" (2020 data are now available for all Daymet Version 4 datasets), and "Sea Water Elevation Profile and Change from Pre-Delta-X Campaign Datasets" (Five Pre-Delta-X Airborne datasets recently published provide sea water level profile and change derived from UAVSAR, AirSWOT, and lidar). Below the news section is a paragraph about the ORNL DAAC mission: "The ORNL DAAC mission is to assemble, distribute, and provide data services for a comprehensive archive of terrestrial biogeochemistry and ecological dynamics observations and models to facilitate research, education, and decision-making in support of NASA's Earth science. Read more about the ORNL DAAC." At the bottom are four boxes with icons and text: "Read about Best Practices in Data Management" (with a "data management" icon), "Browse datasets by Science Theme" (with a "Science Theme" icon), "Retrieve Daymet data with the Single Pixel Extraction Tool" (with a "Single Pixel Extraction Tool" icon), and "Find data products with the Fixed Sites Subsets Tool" (with a "Fixed Sites Subsets Tool" icon).

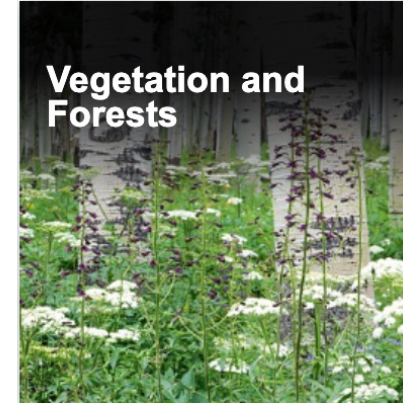
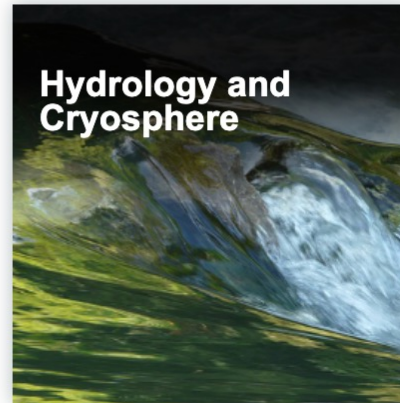
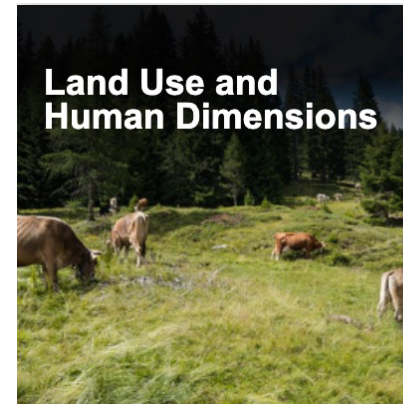
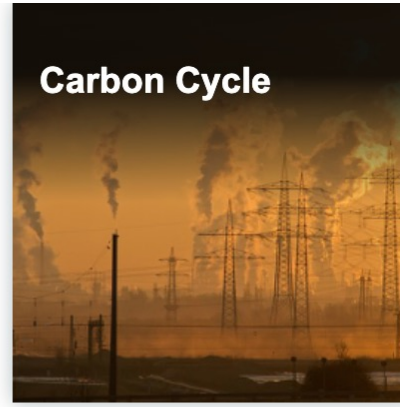


# ORNL DAAC Products: 1,547 1,532 datasets and 15 models (as of July 2021)





# ORNL DAAC Products: Science Themes



# Data Tools and Services at ORNL DAAC

Filter by capability:  Search  Visualize  Subset  Service  Download  Select All

## MODIS

Obtain MODIS Land Product subsets for any location, area, and time period globally.



Visualize



Subset



Service



Download

## THREDDS

Find, visualize, and subset netCDF datasets.



Search



Subset

## Spatial Data Access Tool (SDAT)

Visualize and download geospatial datasets in user-selected file formats, extent, projection, and resolution through OGC standards.



Subset



Service



Visualize

## Daymet

Get daily meteorological data for any North American location.



Visualize



Subset



Service

## Airborne Data Visualizer

View and download in-situ measurements from multiple airborne missions.



Visualize



Download

## Soil Moisture Visualizer

Subset, view, and download harmonized soil moisture data across North America from AirMOSS, SMAP, SoilSCAPE, and other sources.



Visualize



Download



Subset



# Weather and Climatic Variables

- Daymet V4
  - a daily meteorological dataset derived from land surface weather station observations
  - integrating vegetation structure with climatic variables can improve understanding of terrestrial ecosystems

## Data Characteristics

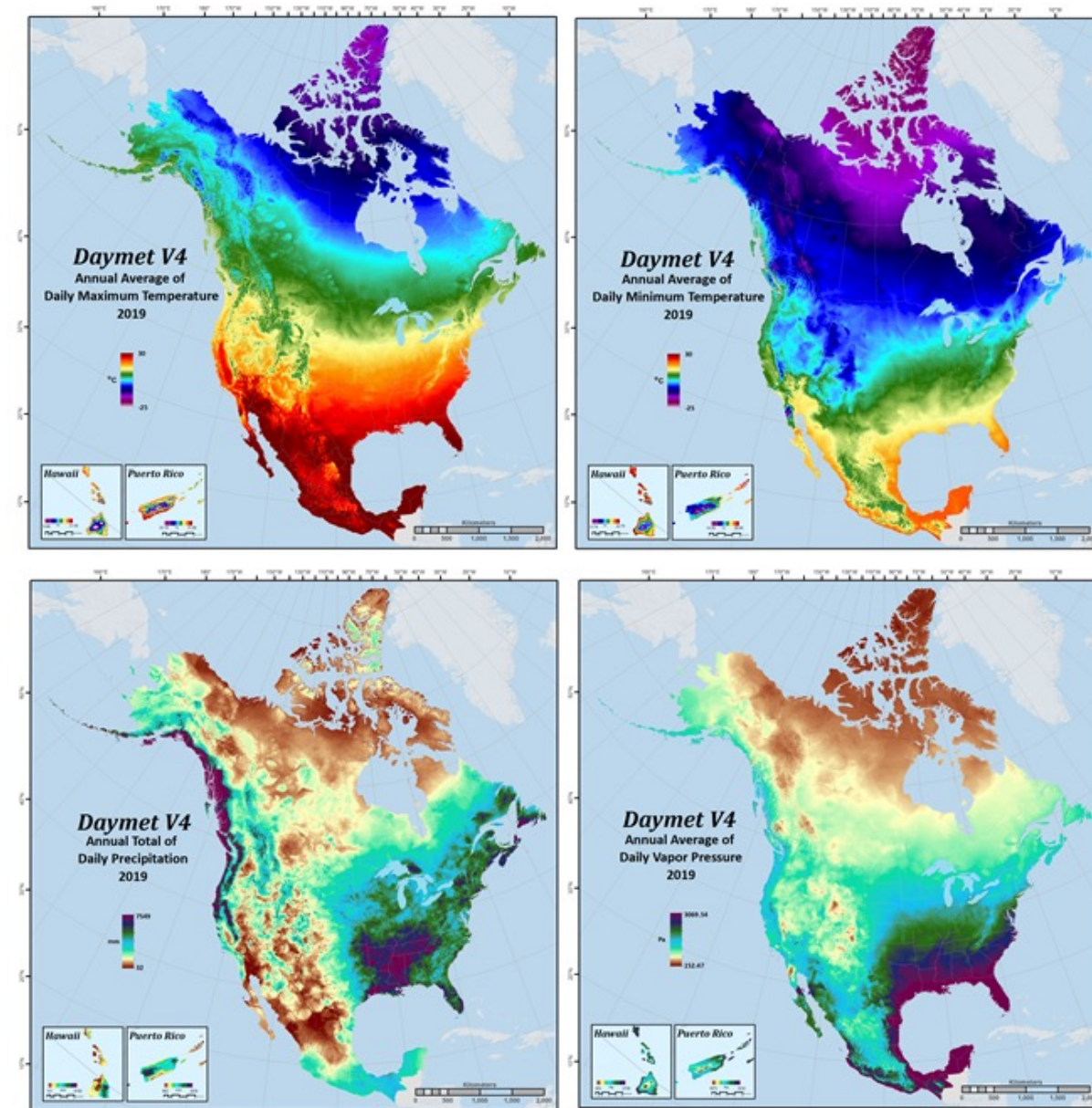
Temporal / Spatial Resolution ..... Daily / 1km x 1 km

Years Available ..... 1980 – 2020

Spatial Region ..... North America, Hawaii, Puerto Rico

### Daymet Data Products

Variable	Units
maximum temperature	°C
minimum temperature	°C
shortwave radiation	W/m <sup>2</sup>
vapor pressure	Pa
snow water equivalent	kg/m <sup>2</sup>
precipitation	mm/day
day length	s/day

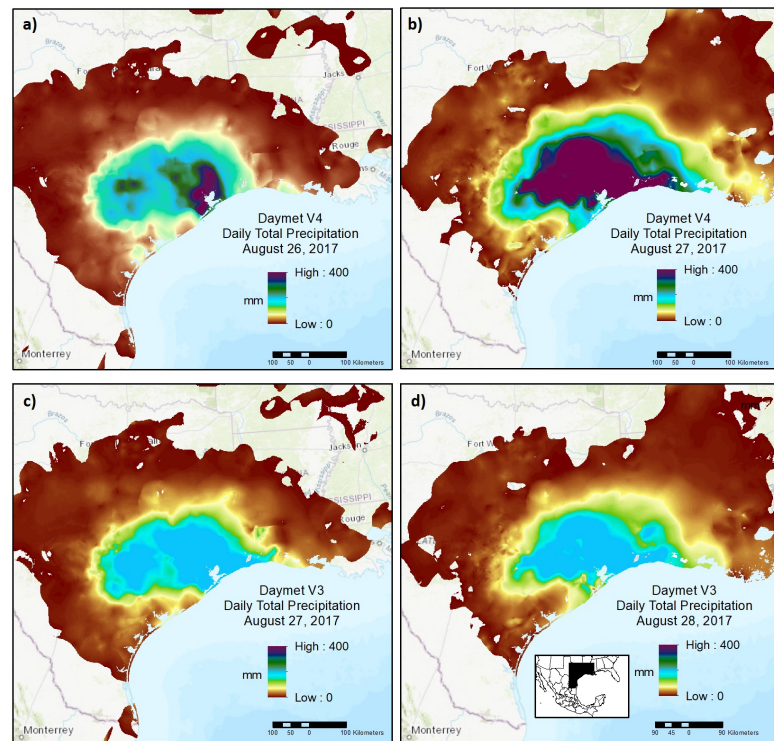




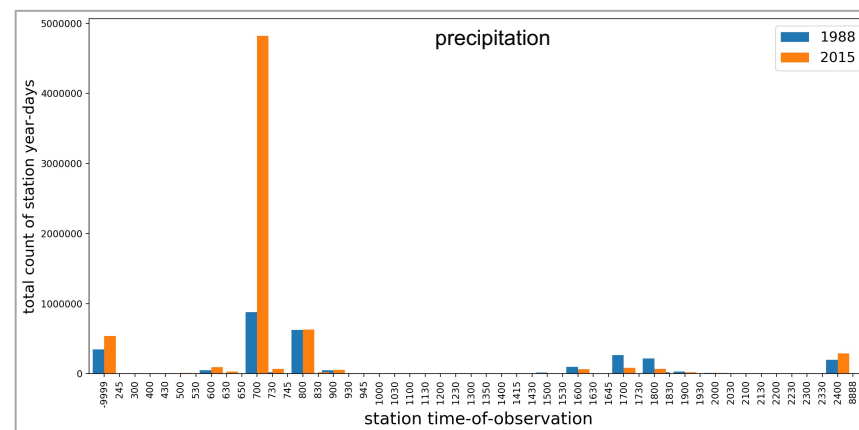
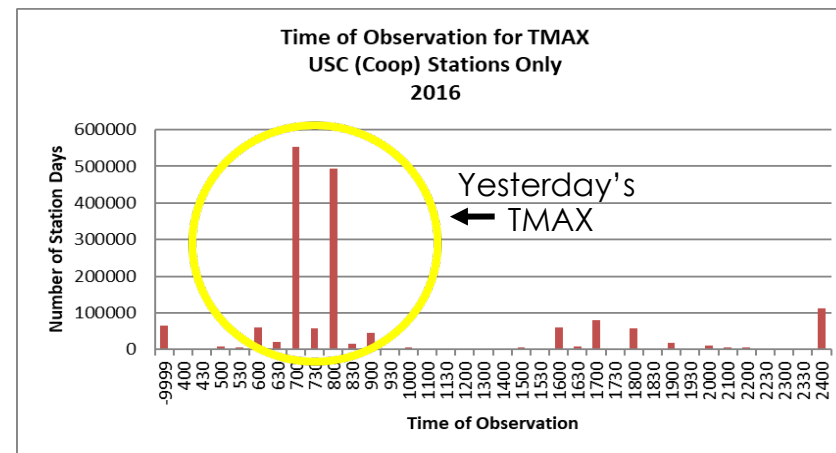
# Daymet V4

- Version 4 – Data Released in December 2020

- Improvements include:
  - improvement to the three-dimensional regression model techniques in the core algorithm
  - reductions in the timing bias of input weather station measurements
  - novel approach to handling high elevation temperature measurement biases



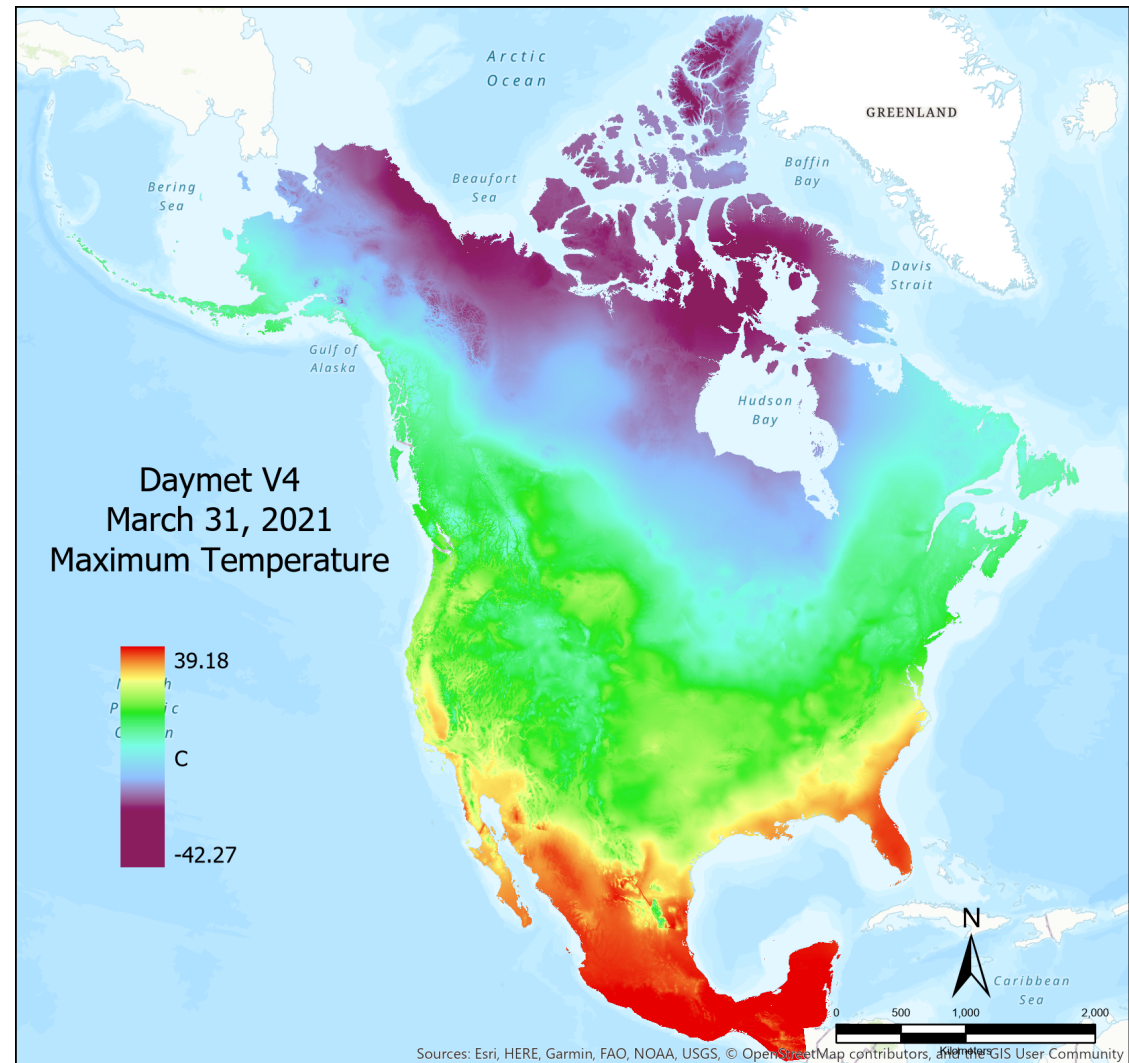
Daily total precipitation for a sub-region that shows landfall of Hurricane Harvey in late August 2017. Top panels show two days from the Daymet V4. Bottom panels show the corresponding days from the V3 dataset. Date shifting based on time-of-observation bias for precipitation are shown.



Thornton, P.E., R. Shrestha, M. Thornton, S.-C. Kao, Y. Wei, B.E. Wilson (2021) Gridded daily weather data for North America with comprehensive uncertainty quantification. *Nature Scientific Data*, DOI: 10.1038/s41597-021-00973-0

# Daymet Version 4 lower-latency data product

- Daymet V4 lower-latency (LL)
  - Starting in Jan, 2021, Daymet daily data is provided on a monthly cycle
  - Published as a separate, provisional dataset
  - Thornton, M.M., R. Shrestha, P.E. Thornton, S. Kao, Y. Wei, and B.E. Wilson. 2021. Daymet Version 4 Monthly Latency: Daily Surface Weather Data. ORNL DAAC, Oak Ridge, Tennessee, USA.  
<https://doi.org/10.3334/ORNLDAAC/1904>

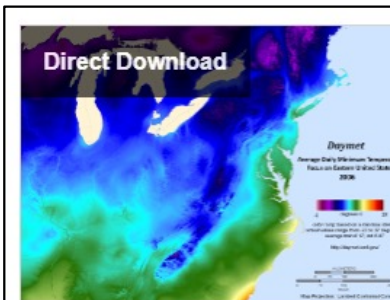




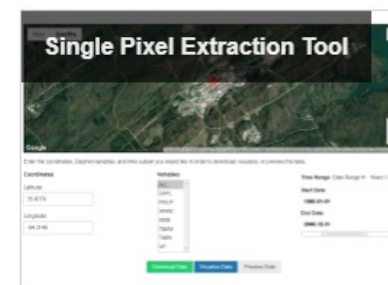
# Daymet

- Daymet V4 Data Access

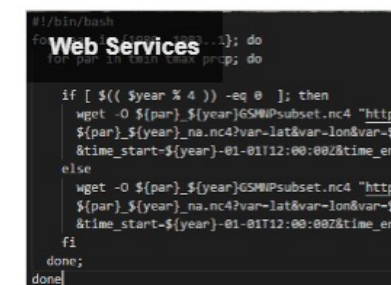
<https://daymet.ornl.gov>



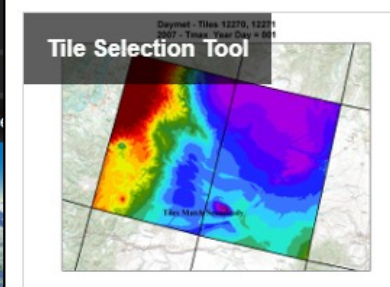
Direct Download



Single Pixel Extraction Tool



Web Services



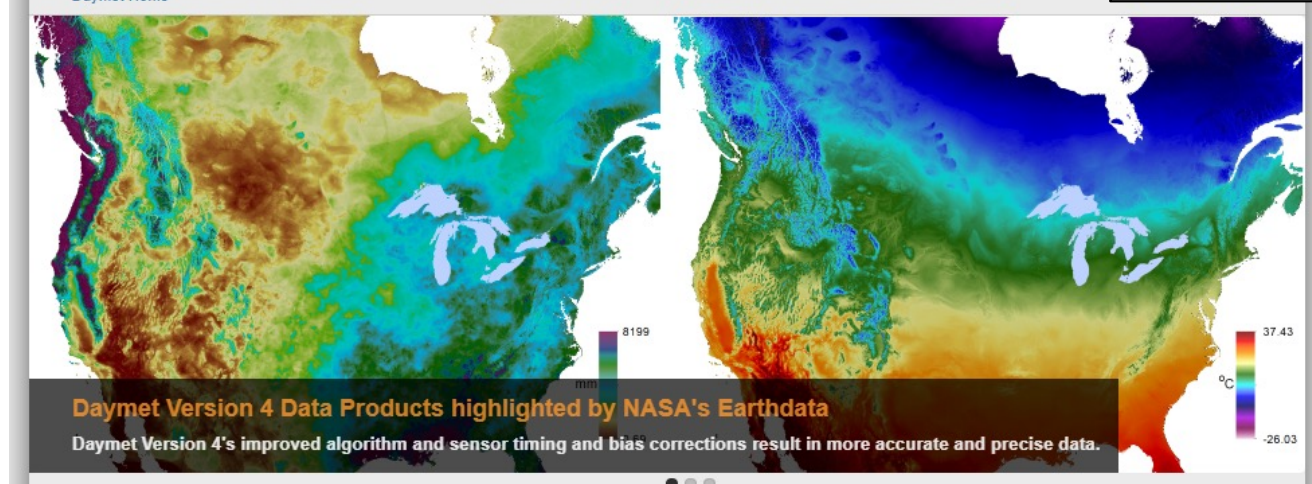
Tile Selection Tool



Climatologies Through SDAT



Fixed Sites Subsets

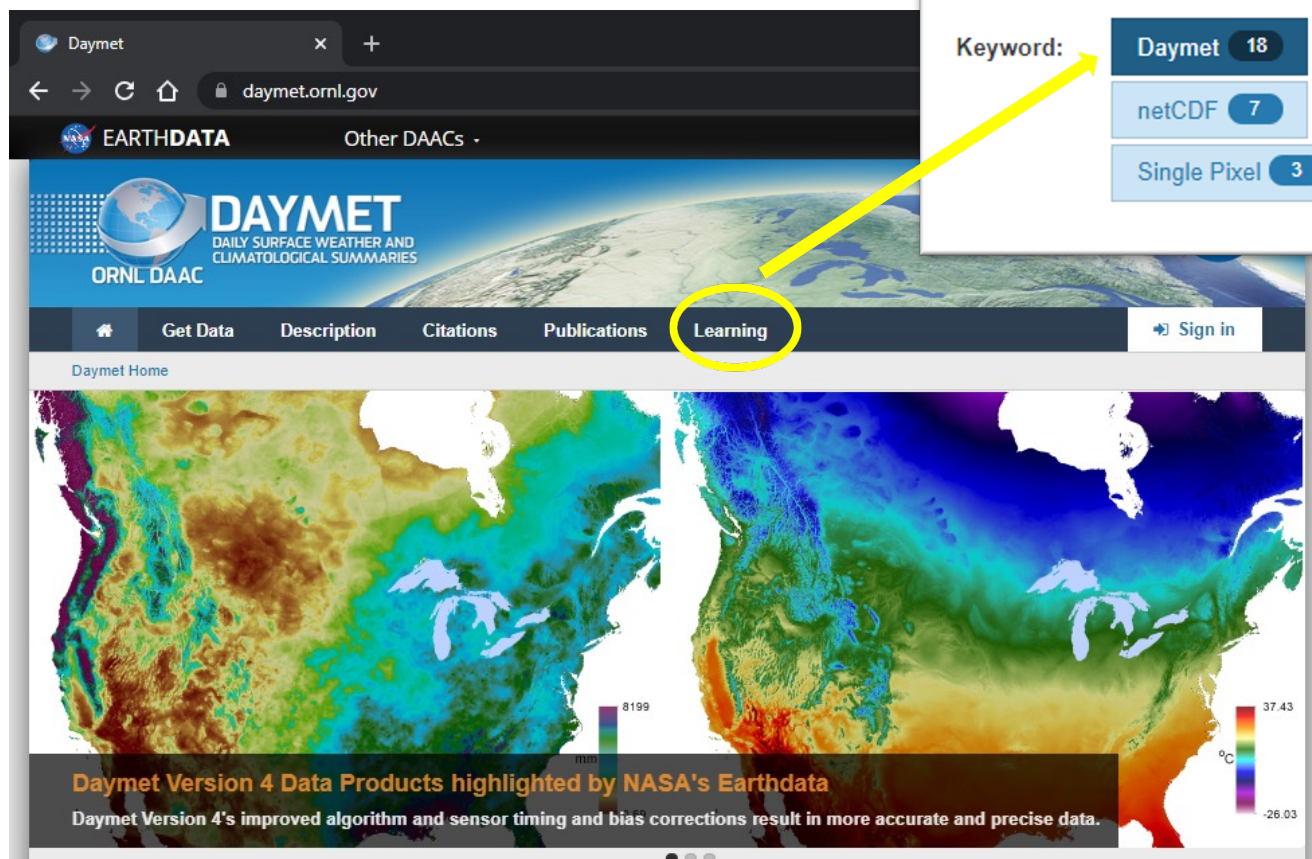




# Daymet

- Daymet V4 Data Access

<https://daymet.ornl.gov>



Type:

Tutorial 8

Webinar 2

Code 5

Help Page 1

Workshop 2

Keyword:

Daymet 18

Python 8

Web Service 7

'R' 4

MODIS/VIIRS 4

OPeNDAP 4

netCDF 7

SDAT 3

THREDDS 4

Data Management 1

ABoVE 0

WMS 0

Single Pixel 3

MATLAB 0

Airborne 0

csv 2

NCSS 2

Bash Script 2

# Daymet/Lidar-SAR Applications in Ecology

- Publications showing synergistic use of Daymet & Lidar/SAR

Article | Published: 29 April 2021





## **Disturbance suppresses the aboveground carbon sink in North American boreal forests**

Jonathan A. Wang , Alessandro Baccini, Mary Farina, James T. Randerson & Mark A. Friedl

*Nature Climate Change* **11**, 435–441 (2021) | [Cite this article](#)

PAPER • OPEN ACCESS

## High-resolution forest carbon modelling for climate mitigation planning over the RGGI region, USA

L Ma<sup>7,1</sup> , G Hurtt<sup>1</sup> , H Tang<sup>1</sup> , R Lamb<sup>1</sup> , E Campbell<sup>2</sup>, R Dubayah<sup>1</sup>, M Guy<sup>1</sup>, W Huang<sup>1,3</sup> , A Lister<sup>4</sup> , J Lu<sup>1</sup>  + [Show full author list](#)

Published 6 April 2021 • © 2021 The Author(s). Published by IOP Publishing Ltd

*Environmental Research Letters*, Volume 16, Number 4

[Translator Disclaimer](#)

21 April 2020

## **Surface soil moisture estimation at high spatial resolution by fusing synthetic aperture radar and optical remote sensing data**

*Nengcheng Chen, Bowen Cheng, Xiang Zhang, Chenjie Xing*

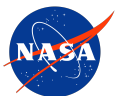
[Author Affiliations +](#)

*J. of Applied Remote Sensing*, **14**(2), 024508 (2020). <https://doi.org/10.1117/1.JRS.14.024508>



# Topographic LiDAR/SAR Datasets at ORNL DAAC

- Airborne & derived Products
- TLS & related
- Space-borne & related
- SAR Datasets





# Raw LiDAR (Processing Levels ~1-2)

Platform	Footprint	Technology	Description	Region	Time Period
Airborne	Large	Full-waveform	<a href="#">BOREAS Scanning Lidar Imager of Canopies by Echo Recovery (SLICER)</a>	Canada	1996
Terrestrial	Small	Discrete return	<a href="#">ECHIDNA LIDAR Campaigns: Forest Canopy Imagery and Field Data</a>	USA	2007-2009
Airborne	Small	Discrete-return	<a href="#">LiDAR Data for Forested Areas in Paragominas, Para</a>	Brazil	2012-2014
Airborne	Small	Discrete-return	<a href="#">LiDAR and DTM Data from Tapajos National Forest in Para</a>	Brazil	2008
Airborne	Small	Discrete-return	<a href="#">LiDAR and DTM Data from Forested Land Near Manaus, Amazonas</a>	Brazil	2008
Airborne	Small	Discrete-return	<a href="#">LiDAR Data for Forested Sites on Borneo Island, Kalimantan</a>	Indonesia	2014
Airborne	Small	Discrete-return	<a href="#">LiDAR Data for Mangrove Forests in the Zambezi River Delta</a>	Mozambique	2014
Airborne	Small	Discrete-return	<a href="#">LiDAR Data, DEM, and Maximum Vegetation Height Product from Southern Idaho</a>	USA	2014
TLS	Small	Discrete return	<a href="#">Terrestrial Lidar Scanning Forest-Tundra Ecotone, Brooks Range, Alaska</a>	USA	2008-2018

# Derived Products (Processing Levels ~3-4) – Regional & Local

- 30+ data products
- Science variables
  - Aboveground biomass (AGB)
  - Canopy height metrics (CHM)
  - Tree cover (TC)
  - Topographic metrics (TM)
  - Vegetation map (VM)

Science Variables*	Resolution	Description	Region	Time Period
AGB	20-50m	LIDAR-derived Estimates of Aboveground Biomass at Four Forested Sites	USA	2011
AGB	500m	LIDAR-based Biomass Estimates, Boreal Forest Biome	Alaska & Canada	2005-2006
AGB	500m	LIDAR-based Biomass Estimates, Boreal Forest Biome	N Eurasia	2005-2006
CHM	30m	LIDAR-derived Vegetation Canopy Structure, Great Smoky Mountains National Park	USA	2005-2006
CHM, TM	30m	Remote Sensing Data Before and After California Rim and King Forest Fires	USA	2010-2015
TM	1m	LIDAR Data for Forested Areas in Paragominas, Para	Brazil	2012-2014
CHM	100m	Canopy Height and Biomass from LIDAR Surveys at La Selva	Costa Rica	1998, 2005
AGB	13m	Aboveground Biomass from Penobscot Experimental Forest, Maine	USA	2012
TC	1m	LIDAR-derived Tree Canopy Cover for States in the Northeast USA	USA	2008, 2013, 2014
CHM	1m	Mangrove Canopy Height Estimates from Remote Imagery, Zambezi Delta	Mozambique	2014
TM	1m	LIDAR and DTM Data from Tapajos National Forest in Para	Brazil	2008
TM	1m	LIDAR and DTM Data from Forested Land Near Manaus, Amazonas	Brazil	2008
AGB, CHM	1m	Aboveground Biomass for Mangrove Forest, Zambezi River Delta	Mozambique	2014
AGB, CHM, TC	30m	LIDAR-derived Biomass, Canopy Height and Cover, Sonoma County, California	USA	2013
CHM, TM	1m	LIDAR Data, DEM, and Maximum Vegetation Height Product from Southern Idaho	USA	2013
AGB, CHM	tree, 30m, 25m	LIDAR-Derived Aboveground Biomass and Uncertainty for California Forests	USA	2005-2014
AGB, CHM	30m	LIDAR Derived Biomass, Canopy Height and Cover for Tri-State (MD, PA, DE) Region	USA	2004-2014
CHM, TM	1m	LIDAR-derived Canopy Height, Elevation for Sites in Kalimantan	Indonesia	2014
AGB	0.8m	High-Resolution Shrub Biomass and Uncertainty Maps, Toolik Lake Area, Alaska	USA	2013
CHM*	Profile	Polarimetric Height Profiles by TomoSAR, Lope and Rabi Forests	Gabon	2016
CHM*	30m	Rainforest Canopy Height Derived from PolInSAR and Lidar Data	Gabon	2016
TM	1m	Permafrost Measurements and Distribution Across the Y-K Delta, Alaska	USA	2016
AGB, CHM, TC	100m	Aboveground Biomass, Landcover, and Degradation, Kalimantan Forests	Indonesia	2014
AGB*	50m	LIDAR and PALSAR-Derived Forest Aboveground Biomass, Paragominas, Para	Brazil	2012
AGB	50m	Forest Aboveground Biomass and Carbon Sequestration Potential for Maryland	USA	2011
AGB	30m	Disturbance History and Forest Biomass from Landsat for Six US Sites	USA	1985-2014
AGB	50m	Aboveground Biomass for Lope, Mabounie, Mondah, and Rabi Sites	Gabon	2010-2016
VM	20cm	High-Resolution Vegetation Community Maps, Toolik Lake Area, Alaska	USA	2013-2015
AGB	30m	Annual Aboveground Biomass Maps for Forests in the Northwestern USA	USA	2000-2016
AGB	30m	LIDAR Biomass Improved for High Biomass Forests, Sonoma County, CA	USA	2013
AGB, CHM, TC, TM	25m	Gridded Forest Biomass and Canopy Metrics Derived from LVIS	Gabon	2016
AGB, TC	100m	Gridded Estimates of Woody Cover and Biomass across Sub-Saharan Africa	Africa	2000-2004
TM	1m	Digital Elevation Models for the Global Change Research Wetland, Maryland	USA	2011
AGB	30m	Annual Aboveground Biomass for Boreal Forests of AB0VE Core Domain	USA	1984-2014
AGB	500m	Aboveground Biomass Change for Amazon Basin, Mexico, and Pantropical Belt	Pantropical	2003-2016
AGB	30m	LIDAR Derived Biomass, Canopy Height, and Cover for New England Region	USA	2015

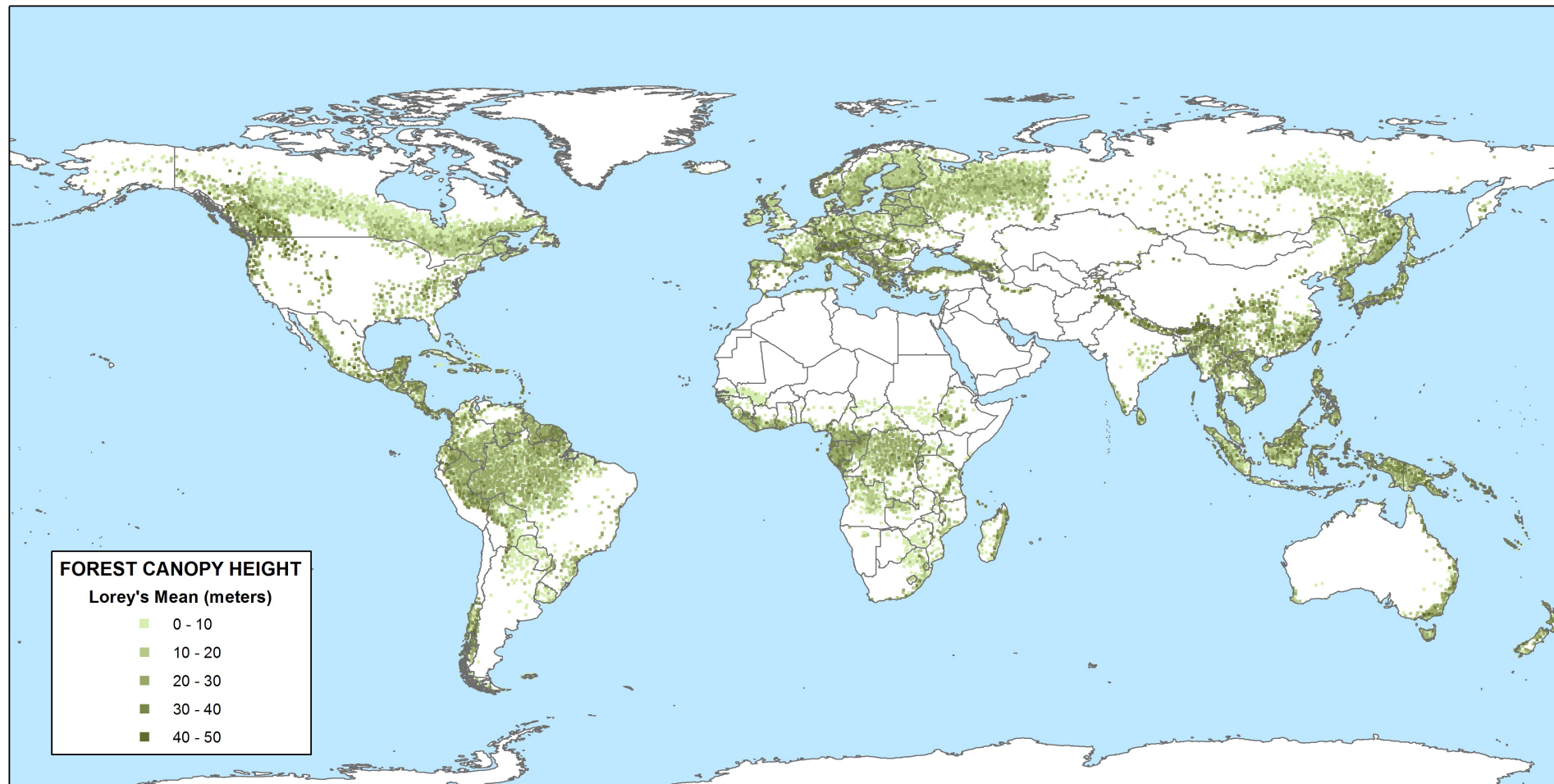
# Derived Products (Processing Levels ~3-4) - Global

Science Variables*	Resolution	Description	Time Period
CHM	Site	<a href="#">GLAS LiDAR-derived Global Estimates of Forest Canopy Height</a>	2004-2008
AGB, CHM	30m	<a href="#">Global Mangrove Distribution, Aboveground Biomass, and Canopy Height</a>	2000-2009
CHM, TM	1000m	<a href="#">GED1 L3 Gridded Land Surface Metrics</a>	2019-2020
CHM\$	1000m	<a href="#">Global 1km Forest Canopy Height</a>	2011

AGB = aboveground biomass; CHM = canopy height metrics; TC = tree cover; TM = topographic metrics

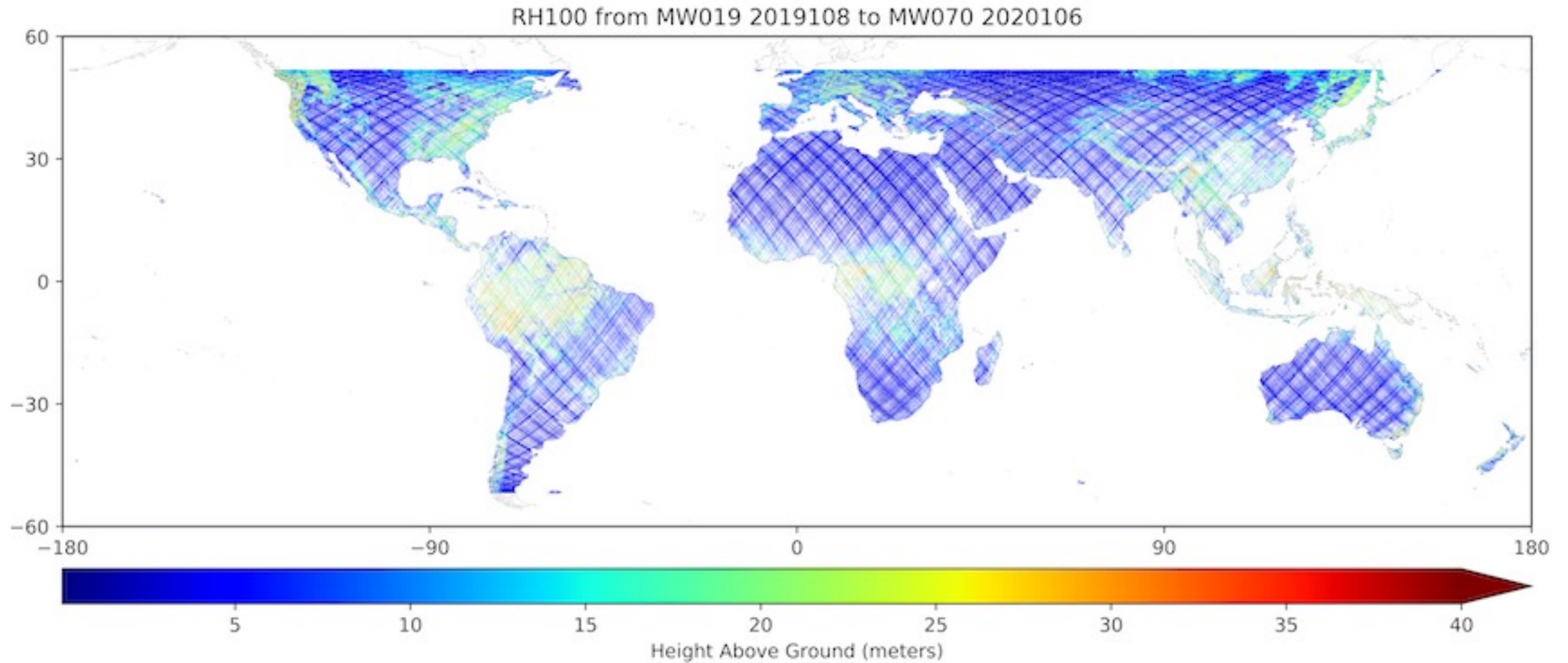


# GLAS LiDAR-derived Global Estimates of Forest Canopy Height, 2004-2008



**Dataset:** Healey et al., 2015. <https://doi.org/10.3334/ORNLDAAAC/1271>

# GEDI L3 Gridded Land Surface Metrics

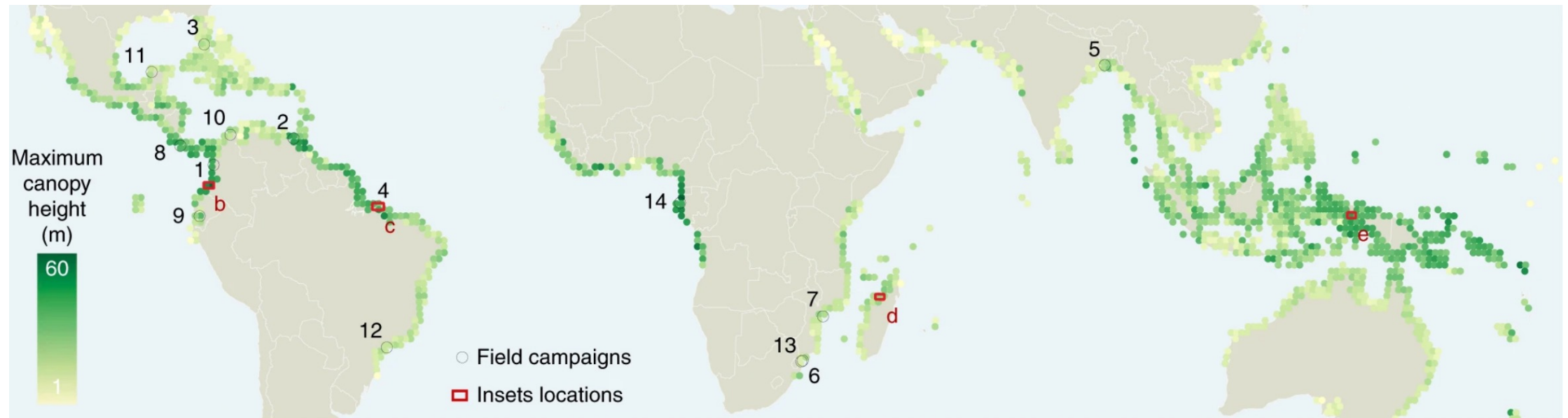


**Dataset:** Dubayah et al., 2021. <https://doi.org/10.3334/ORNLDAAAC/1865>

**Method:** Luthcke et al., 2021.

[https://daac.ornl.gov/daacdata/gedi/GEDI\\_L3\\_Land\\_Surface\\_Metrics/comp/GEDI\\_ATBD\\_L3R01.pdf](https://daac.ornl.gov/daacdata/gedi/GEDI_L3_Land_Surface_Metrics/comp/GEDI_ATBD_L3R01.pdf)

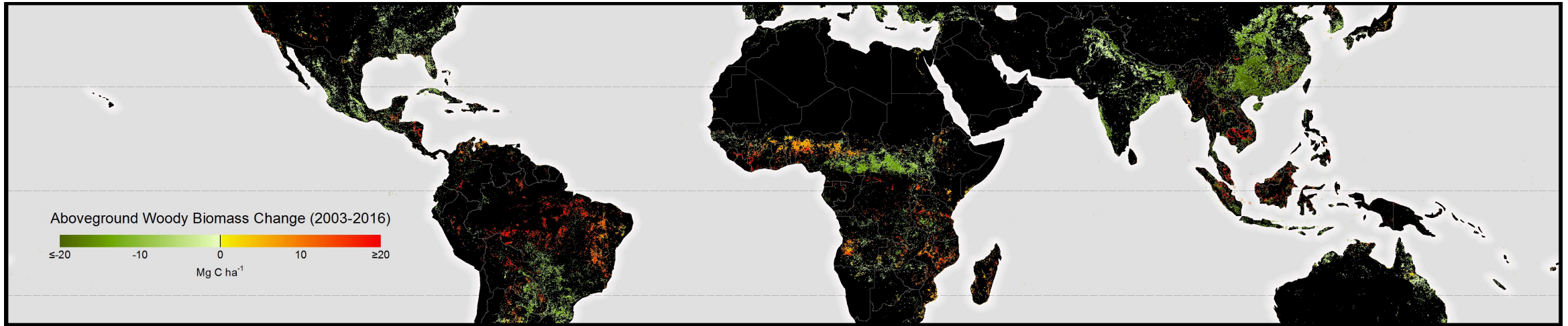
# Global Mangrove Distribution, Aboveground Biomass, and Canopy Height



**Dataset:** Simrad et al., 2019. <https://doi.org/10.3334/ORNLDAAAC/1665>

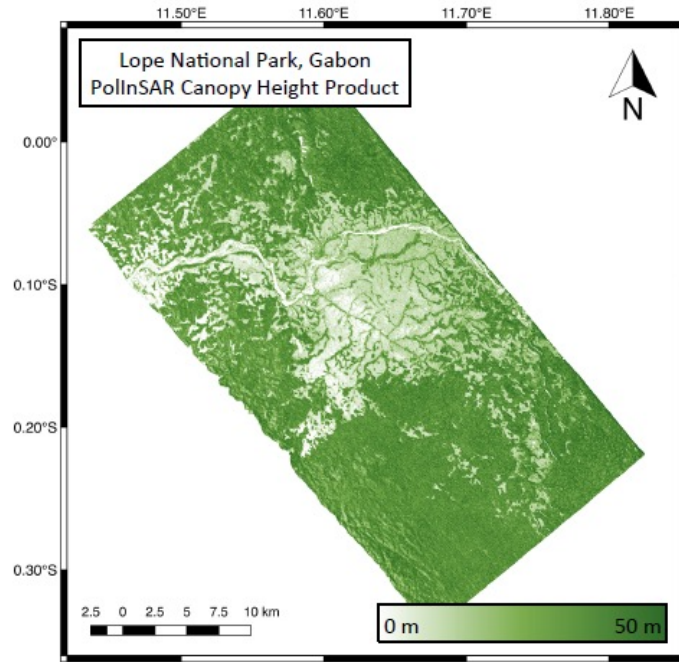


# Aboveground Biomass Change for Amazon Basin, Mexico, and Pantropical Belt, 2003-2016



**Dataset:** Baccini et al., 2019. <https://doi.org/10.3334/ORNLDAAAC/1824>

# Synergistic Applications: SAR and LiDAR



Fusion of polarimetric synthetic aperture radar interferometry (PolInSAR) and land, vegetation, and ice sensor (LVIS) lidar data for canopy height estimation

**Dataset:** Denbina et al., 2018. <https://doi.org/10.3334/ORNLDAAAC/1589>

**Method:** Denbina et al., 2018. <https://doi.org/10.1109/JSTARS.2018.2841388>